CLAIMS

I claim:

1 A process for reducing a concentration of nitrogen oxides, NO_x, in an effluent gas stream from a combustion of liquid or gaseous carbonaceous fuel in a gas turbine combustion chamber, comprising the steps of:

identifying a gas combustion temperature zone within said combustion chamber that is downstream of a zone of initial gasification of said liquid fuel and initial combustion of said liquid or gaseous carbonaceous fuel and where in an absence of any steps to cool a downstream gas temperature zone, approximately above 2500°F, thermal NO_x production is provided;

injecting water droplets of varying size between 10 μm to 1000 μm by means of one or more nozzles that form a flat, planar, fan shaped, spray pattern which is oriented perpendicular to said effluent gas stream and is of cross-sectional area to intercept all of the effluent gas stream in said gas combustion temperature zone; and whose mean and maximum size of said droplets depend on the dimensions of said gas combustion temperature zone in said chamber,

varying hydraulic or air atomizing pressure in at least one injector in order to permit distribution and vaporization of different sized droplets at different locations within said gas combustion temperature zone, taking place during said injecting step and

adjusting a position of an injector droplet outlet of said at least one injector within said combustion chamber based on an outer edge of said gas combustion temperature zone identified in said identifying step, said adjusting step positioning said injector

droplet outlet adjacent to said outer edge of said gas combustion temperature zone identified in said identifying step,

with evaporation of said flat, planar, fan-shaped, spray pattern cooling said gas combustion temperature zone within said combustion chamber to temperatures, approximately below 2500°F, where thermal NO_x production is suppressed.

2 A process for reducing the concentration of nitrogen oxides, NO_x, in an effluent gas stream from combustion of liquid or gaseous carbonaceous fuel in a gas turbine combustion chamber comprising the steps of:

identifying a gas combustion temperature zone within said combustion chamber that is downstream of a zone of initial gasification of said liquid fuel and initial combustion of said liquid or gaseous carbonaceous fuel and where in absence of any steps to cool downstream gas in said gas combustion temperature zone, approximately above 2500°F, thermal NO_x production is favored;

injecting water droplets of varying size between 10 μm to 1000 μm by means of one or more nozzles that form a conical spray pattern which is opposed in a case of larger mean droplet size or in a direction in the case of smaller mean droplet size to an average velocity vector of said effluent gas stream and is of cross-sectional area to intercept all of the effluent gas stream in said gas combustion temperature zone; and whose mean and maximum size of said droplets depend on the dimensions of said gas combustion temperature zone in said combustion chamber,

varying hydraulic or air atomizing pressure in an injector in order to permit distribution and vaporization of different sized droplets at different locations within said gas combustion temperature zone, taking place during said injecting step and

adjusting a position of an injector droplet outlet of said injector within said combustion chamber based on an outer edge of said gas combustion temperature zone identified in said identifying step, said adjusting step positioning said injector droplet outlet adjacent to said outer edge of said gas combustion temperature zone identified in said identifying step,

with evaporation of said conical spray pattern cooling said gas combustion temperature zone within chamber to temperatures, approximately below 2500°F, where thermal NO_x production is suppressed.

3. A process for reducing the concentration of nitrogen oxides, NO_x, in an effluent gas stream from combustion of liquid or gaseous carbonaceous fuel in a gas turbine combustion chamber comprising the steps of:

identifying a gas combustion temperature zone within said combustion chamber whose gas temperature is between 1700°F and 2200°F and that is immediately downstream of the gas combustion temperature zone of initial gasification of said liquid fuel and initial combustion of said liquid or gaseous carbonaceous fuel;

injecting water droplets, containing an aqueous solution of a NO_x reducing agent, including one of ammonia and urea, of varying size between 10 μm to 1000 μm by means of one or more nozzles that form a flat, planar, fan shaped spray pattern which is

oriented perpendicular to said effluent gas stream and is of sufficient cross-sectional area to intercept all of the effluent gas stream in a downstream combustion temperature zone; and whose mean and maximum size of said droplets depend on the dimensions of said downstream gas temperature zone in said combustion chamber,

varying hydraulic or air atomizing pressure in an injector in order to permit distribution and vaporization of different sized droplets at different locations within said gas combustion temperature zone, taking place during said injecting step and

adjusting a position of an injector droplet outlet of said injector within said combustion chamber based on an outer edge of said downstream combustion temperature zone identified in said identifying step, said adjusting step positioning said injector droplet outlet adjacent to said outer edge of said gas combustion temperature zone identified in said identifying step,

with subsequent to evaporation of said droplets in said downstream combustion gas temperature zone, said NO_x reducing reagent reacting with the NO_x molecules and converting them to N_2.

4. A process for reducing the concentration of nitrogen oxides, NO_x, in an effluent gas stream from the combustion of liquid or gaseous carbonaceous fuel in a gas turbine combustion chamber comprising the steps of:

identifying a gas combustion temperature zone within said combustion chamber whose gas temperature is between 1700°F and 2200°F and that is immediately

downstream of a gas combustion temperature zone of initial gasification of said liquid fuel and initial combustion of said liquid or gaseous carbonaceous fuel;

injecting water droplets, containing an aqueous solution of a NO_x reducing agent, including one of ammonia and urea, of varying size, between 10 μm to 1000 μm, by means of one or more nozzles that form a conical spray pattern which is either opposed in a case of larger mean droplet size or in a direction in a case of smaller mean droplet size to the average velocity vector of said effluent gas stream and is of sufficient cross-sectional area to intercept all of the effluent gas stream in said downstream gas combustion temperature zone; and whose mean and maximum size of said droplets depend on the dimensions of said gas temperature zone in said chamber ,

a producing step taking place during said injecting step by varying hydraulic or air atomizing pressure in an injector in order to permit distribution and vaporization of different sized droplets at different locations within said gas combustion temperature zone, and

adjusting a position of an injector droplet outlet of an injector within said combustion chamber based on an outer edge of said gas combustion temperature zone identified in said identifying step, said adjusting step positioning said injector droplet outlet adjacent to said outer edge of said downstream gas temperature zone identified in said identifying step,

with subsequent to evaporation of said droplets in said downstream combustion gas temperature zone, said NO_x reducing reagent reacting with the NO_x molecules and converting them to N_2.

5. A process in accordance with claim 1, where each injector has an atomizing air chamber with outlets for said droplets and inlets for liquid and air and each of said injectors are connected to a pipe that contains pressurized water, and a parallel compressed air pipe, where said air pipe and liquid filled pipe are each placed inside and co-axially within a pipe containing water flowing at sufficient rates to prevent boiling of said water in the pipes and inside droplets injector head which is placed in contact with the said hot gas temperatures, said outer water cooling flow pipes terminate a distance upstream of said compressed air and solution filled pipes, thereby allowing the cooling water to exit the outer cooling pipes and cool a rear of the injector head by evaporative cooling, with a balance of the outer cooling water flow entering the combustion chamber being treated and evaporating.

6. A process in accordance with claim 1, where said gas combustion temperature zone is determined by means of a thermocouple with either a bare exposed tip inserted into said effluent gas stream being treated, or with said thermocouple tip being recessed within a ceramic tube where said ceramic tube is held in place in a hollow metal pipe, which is connected to a vacuum source which draws the combustion gas into the ceramic tube and around the thermocouple tip.

7. A process in accordance with claim 6, wherein the metal pipe encloses thermocouple wires, and is surrounded by a water cooled, metal annular jacket in which

cold inlet water flows through the outer annulus, turns 180° in an end cap, and returns through an inner annulus, where the tube wall of said inner annulus being the tube that contains said thermocouple wires.

8. A process in accordance with claim 1, where injector feed pipes to said at least one injector are each cooled by an external, coaxial jacket pipe having flowing water, at a rate controlled by flow meters, pressure gauges and valves.

9. A process in accordance with claim 1, further comprising the step of inserting said at least one injector either through pre-existing ports or by installing new access ports into said gas turbine combustion chamber.

10. A process in accordance with claim 1, wherein hydraulic injectors producing either a flat fan spray or a conical spray, are used in place of air atomized injectors, and whose flow capacity and droplet size distribution depends on the size of the combustion gas temperature zone.

11. A process in accordance with claim 5, where one or more air atomized droplet injectors are used to produce very fine droplets, less than 100 microns in diameter,

for the injection of the liquid fuel into the combustion zone immediately downstream of said injector,

said combustion zone being immediately upstream of the combustion gas zone,

with said fuel droplet size being selected so as to maximize a rate at which said droplets are vaporized and react with combustion air to reach temperatures of about 3000°F, thereby minimizing unburned hydrocarbons and carbon monoxide formation both in said 3000°F zone and in an immediately downstream combustion zone and reducing thermal NO_x formation by minimizing the gas residence time in said 3000°F zone.

12. A process in accordance with claim 4, wherein the NO_x reducing reagents are dissolved and mixed with water, and further mixed with liquids including one of isopropyl alcohol and methanol that bind with water molecules, and a final solution being mixed with the liquid gas fuel, and injected in regions away from bulk of the liquid or gaseous gas carbonaceous fuel and a hottest part of the gas combustion chamber in order for the NO_x reducing agent, to react with and reduce the NO_x.

13. A process in accordance with claim 3, wherein the NO_x reducing reagents, are dissolved and mixed with water, and further mixed with liquids including one of isopropyl alcohol and methanol that bind with water molecules, and said solution being injected in a zone where gas temperatures favor the NO_x reducing reactions between approximately 1700°F and 2200°F.

14. A process in accordance with claim 4, wherein the NO_x reducing reagents, are dissolved and mixed with water, and further mixed with liquids including one of

isopropyl alcohol and methanol that bind with water molecules, and said solution being injected in a zone where gas temperatures favor the NO_x reducing reactions between approximately 1700°F and 2200°F.

15. A process in accordance with claim 1, comprising maximizing the combined NO_x emission reduction and minimizing the CO and unburned hydrocarbon emissions.

16. A process in accordance with claim 3, wherein additional fuel is injected at an upstream end of the downstream combustion temperature zone in order to convert said downstream combustion temperature zone to slightly fuel rich conditions, to reduce NO_x.

17. A process in accordance with claim 4, wherein additional fuel is injected at an upstream end of the downstream combustion temperature zone in order to convert said downstream combustion temperature zone to slightly fuel rich conditions, to reduce NO_x.

18. A step in accordance with claim 13, wherein additional fuel is mixed with NO_x reducing agents reacts and the combined liquid is injected at an upstream end of the downstream combustion temperature zone and into a reburn combustion zone to effect a conversion of fuel lean gas to fuel rich gas, with said reburn combustion zone being heated by several hundred degrees Fahrenheit above a 2200°F ceiling when the NO_x reducing reagent is injected into a fuel lean zone.

19. A process in accordance with claim 16, wherein the NO_x reducing reagents are injected slightly downstream of the reburn fuel at a location where the local gas conditions are fuel rich.

20. A step in accordance with claim 16, wherein final combustion air is introduced immediately downstream of said fuel rich reburn zone to effect final combustion.

21. A process in accordance with claim 16, wherein passages for entry of compressed air into a primary and immediate post primary combustion zones are limited to maintain local gas conditions slightly fuel lean, approximately 10% to no more than 20%.